

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-079494

(43)Date of publication of application : 21.03.2000

(51)Int.Cl. B23K 35/26  
C22C 12/00  
C22C 13/02  
H05K 3/34

(21)Application number : 11-180053

(71)Applicant : FUJI ELECTRIC CO LTD

(22)Date of filing : 25.06.1999

(72)Inventor : YAMASHITA MITSUO  
TADA SHINJI  
SHIOKAWA KUNIO

(30)Priority

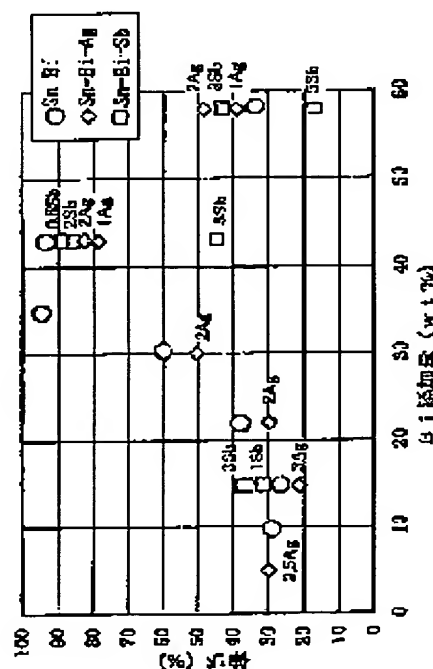
Priority number : 10186534 Priority date : 01.07.1998 Priority country : JP

## (54) SOLDER

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain unleaded low-melting point solder which is also superior in ductility, heat resistance and wettability by improving tin-bismuth Sn-Bi alloy.

SOLUTION: This solder contains tin as the main component, 30-58 wt.% bismuth, 5 wt.% or less silver, and 0.3 wt.% or less germanium. This solder may also contain 0.2 wt.% or less nickel and 1% or less copper, in addition to tin, bismuth and silver as prescribed above.



## LEGAL STATUS

[Date of request for examination] 12.04.2001

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3386009  
[Date of registration] 10.01.2003  
[Number of appeal against examiner's decision  
of rejection]  
[Date of requesting appeal against examiner's  
decision of rejection]  
[Date of extinction of right]

Copyright (C); 1998,2003 Japan Patent Office

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**CLAIMS**

---

[Claim(s)]

[Claim 1] The "solder" which makes tin a principal component and is characterized by containing [ a bismuth ] germanium for silver 0.3 or less % of the weight 5 or less % of the weight 30 or 58% of the weight.

[Claim 2] The "solder" which makes tin a principal component and is characterized by containing silver for a bismuth 30 or 58% of the weight, and containing copper for nickel 1 or less % of the weight 0.2 or less % of the weight 5 or less % of the weight.

[Claim 3] The "solder" which makes tin a principal component and is characterized by containing germanium for silver 5 or less % of the weight 30 or 58% of the weight, and containing [ a bismuth ] copper for nickel 1 or less % of the weight 0.2 or less % of the weight 0.3 or less % of the weight.

---

[Translation done.]

## \* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention does not have pollution without starting the "solder" used in metal junction of electronic equipment, especially containing lead, and it relates to eco-friendly "solder."

[0002]

[Description of the Prior Art] In case it joins by solder in electronic equipment etc., while a "solder" has a desired virtual junction temperature, to excel in that the wettability at the time of junction is good and ductility, thermal-fatigue intensity, and corrosion resistance is demanded. Moreover, a "solder" is wanted not to contain lead from the consideration on environment. As conventional "solder", it is tin - Lead Sn-Pb An alloy, tin - Silver Sn-Ag An alloy, tin - Antimony Sn-Sb An alloy, tin - Bismuth Sn-Bi A system alloy etc. is raised.

[0003]

[Problem(s) to be Solved by the Invention] Typical tin - Lead Sn-Pb Since 63Sn-37Pb (eutectic-temperature 183 \*\*) which is an alloy contains lead, it causes lead pollution and is not eco-friendly. When "joining by solder" an electronic instrument by solder, in order to use two or more kinds of equipment from which virtual junction temperature differs constitutionally of "solders" over multiple times and to guarantee the reliability of semiconductor parts further, the thermo-cycle endurance to near peak temperature 125 \*\* is required for semiconductor parts.

[0004] 63Sn-37Pb Sn-Ag which is the typical lead free solder replaced with an alloy (eutectic-temperature 183 \*\*) An eutectic temperature an alloy It is 221 degrees C (3.5 weight % silver), and is Sn-Sb. Melting temperature about an alloy It is 232-245 \*\*. With a lead free alloy, this has high melting temperature, at the time of soldering work, may heat electronic parts too much and may do an injury. Therefore, a melting point is Sn-Ag as lead free solder. An alloy and Sn-Sb It is lower than an alloy and the solder of low melting temperature which can be soldered without these alloys' fusing, when soldering with which it sets like an assembler and virtual junction temperature differs is needed is needed.

[0005] Sn-In which is a lead free-lancer and added the indium by using tin as the base as a low "a solder" of melting temperature The alloy is examined. Sn-In The eutectic point an alloy It is 118 degrees C. Bi-In which is the low temperature "a solder" of the lead free-lancer of further others The eutectic point of an alloy is 75 degrees C. A lead free-lancer's low temperature "a solder" mentioned above has heat-resistant too low temperature. Tin - Bismuth Sn-Bi Sn7.5Bi2Ag0.5Cu which is one of the system alloys Melting temperature is 200-220 \*\*, and an alloy requires 240-250 \*\* as a virtual junction temperature, and produces it in the case where heat electronic parts too much for this reason, and an injury is done. Moreover, Sn7.5Bi2Ag0.5Cu Depending on parts, ductility is low, there is a problem on processability or intensity, the solid-liquid coexistence field of the liquidus line/solidus line may produce the concentration segregation of a bismuth widely further at the time of junction, and what contains a bismuth several% like an alloy may produce ablation.

[0006] Drawing 1 is conventional tin - Bismuth Sn-Bi It is the diagram showing Bi addition (% of the weight) dependency of elongation (%) per system alloy. O in drawing -- Sn-Bi The

characteristic point which an alloy shows, the characteristic point an Sn-Bi-Ag alloy indicates <> to be, and a mouth are characteristic points which a Sn-Bi-Sb alloy shows. the rate of strain in elongation measurement -- 0.2 %/s it is . Sn-Bi The ductility of an alloy (O) will be dwindled towards eutectic composition (Bi58 weight %), if it passes over increase and a peak with Bi addition. The melting point in eutectic composition It is 139 degrees C. Bi 30-50 At the range of weight %, it is Sn-Bi. The elongation of an alloy is 50-90 %. Sn-Ag Elongation is 20-30 %, and an alloy (3.5 weight % silver) is a lead free-lancer's tin. - Bismuth Sn-Bi When it takes into consideration that Sn7.5Bi2Ag0.5Cu (melting temperature is abbreviation 200 degree C) which is a system alloy is extended, and 10% is shown, it is Sn-Bi in the range of Bi30-50 %. The elongation of an alloy is fully large. This is Sn-Pb. It is the ductility of a "solder" and equivalent level. The ductility of an Sn-Bi-Ag alloy (<>) is Sn-Bi at the range of 30 to 58 % of the weight of Bi(s). Although there is an inclination to fall from an alloy (O), it turns out that it is still large fully.

[0007] It is Bi to Sn 30 or Sn-Bi added 58% of the weight Although ductility of an alloy is good as mentioned above, it is known that melting temperature is also still lower. They are Sb and Ag further about such Bi to 30 or the Sn-Bi alloy included 58% of the weight. Or Sn-Bi obtained when germanium was added The thermal resistance (even inside creep property) of a system alloy improves. However, when adding the inside Sb and germanium of Sb, Ag, or germanium, wettability was bad, and when adding Ag and germanium, thermal resistance had the problem that wettability was not clear, although improved.

[0008] the point above-mentioned [ this invention ] -- taking an example -- \*\* -- the purpose -- the low melting point -- ductile good tin-bismuth Sn-Bi the lead which improves an alloy and is excellent in the top where the melting point is low and ductility is good also at thermal resistance and wettability -- it is in offering the free low melting point "a solder"

[0009]

[Means for Solving the Problem] the above-mentioned purpose -- eye the first -- invention -- if it depends, tin will be made into a principal component, and it is attained by containing [ a bismuth ] germanium for silver 0.3 or less % of the weight 5 or less % of the weight 30 or 58% of the weight According to the second invention, tin is made into a principal component, and it is attained by containing silver for a bismuth 30 or 58% of the weight, and containing copper for nickel 1 or less % of the weight 0.2 or less % of the weight 5 or less % of the weight.

[0010] According to the third invention, tin is made into a principal component, and a bismuth is attained by containing germanium for silver 5 or less % of the weight 30 or 58% of the weight, and containing copper for nickel 1 or less % of the weight 0.2 or less % of the weight 0.3 or less % of the weight. Tin is made into a principal component and it is a bismuth 30 or tin-bismuth Sn-Bi contained 58% of the weight Melting temperature an alloy \*\* [ there is no 140 ] Sn-Bi which is in nearly 180 degrees C and added other metallic elements A system alloy turns into a "solder" of the low melting point.

[0011] Tin is made into a principal component and it is 30 or tin contained 58% of the weight about a bismuth. - Bismuth Sn-Bi The ductility of a system alloy is Sn-Pb. They are a "solder" and equivalent level. Tin is made into a principal component and it is 30 or tin contained 58% of the weight about a bismuth. - If Ag, germanium, and nickel and Cu are added at a predetermined rate into a pith mass Sn-Bi alloy, in addition to a melting temperature property or ductility, good "solder" of heat-resistant and wettability will be obtained further. [ Ag, germanium, Ag, nickel and Cu, or ] .

[0012]

[Embodiments of the Invention] A "solder" is Sn, Bi, Ag, germanium, nickel, and Cu. Each raw material can be dissolved and prepared in an electric furnace. Each raw material is purity 99.99. The thing more than weight % was used. Sn is a principal component among "solder" components. For BI, 30 or 58 % of the weight or less, and Ag are 5. Below weight % and germanium are 0.3. Below weight % and nickel are 0.2. Below weight % and Cu are 1. Below weight % is added. Alloy composition makes Sn a principal component and is Bi30, or 58 or less % of the weight and Ag5. Below weight % and germanium0.3 The thing containing below weight %, They are Bi30, or 58 or less % of the weight and Ag5, using Sn as a principal component. Below weight %

and nickel 0.2 Below weight % and Cu 1 The thing containing below weight %, They are Bi 30, or 58 or less % of the weight and Ag 5, using Sn as a principal component furthermore. Below weight % and germanium 0.3 Below weight % and nickel 0.2 Below weight % and Cu 1 Below weight % is included.

[0013] An example tensile strength examination is the diameter of 3mm. A test piece is used and it is hauling speed 0.2 %/s. It carried out in the room temperature. Moreover, in order to investigate thermal resistance, an isomorphism-like test piece is used, and it is 2 0.2kg [/mm ] load stress. The deformation resistance of a creep was measured. Meniscography estimated wettability. The result which got wet and measured the force is [ an Sn22Bi alloy system or / tensile strength, elongation, a creep deformation resistance, and ] Table 1 per Sn43Bi alloy system as an example. It is shown.

[0014]

[Table 1]

材 料 組 成	凝固開始／固相 (℃)	引張り強度 (kg/mm <sup>2</sup> )	伸 び (%)	クリープ変形抵抗 (%/h)100℃	濡れ力 (mN) 230℃
Sn22Bi	202/138	8.3	38	2.2	
Sn22Bi2Ag0.2Ni	194/136	6.4	2.4		1.23
Sn43Bi	167/139	5.5	93	6.0	0.91
Sn43Bi1Ag	158/135	5.9	79		
Sn43Bi2Ag	160/136	6.0	84	5.4	1.08
Sn43Bi5Ag	159/138	6.2	79		
Sn43Bi2Ag0.05Ge	161/138	7.0	86	4.5	1.2
Sn43Bi2Ag0.1Ge	162/138	6.6	73	2.9	
Sn43Bi2Ag0.5Cu0.1Ni	160/138	7.5	70	4.5	0.99
Sn43Bi2Ag0.5Cu0.1Ni0.05Ge	159/138	6.7	58	4.2	1.21
Sn43Bi2Sb	182/141	5.9	87	4.3	0.76
Sn43Bi2Sb0.1Ni	175/140	6.2	2.9		
Sn58Bi	139	8.4	35	3.3	0.75
Sn58Bi2Ag	139	7.0	49	2.7	0.82
Sn58Bi2Ag0.05Ge	140/138	6.5	46	2.3	1.02
Sn58Bi2Ag0.5Cu0.1Ni	143/138	5.9	63	1.9	0.93
Sn58Bi2Ag0.5Cu0.1Ni0.05Ge	140/136	6.1	59	1.6	1.08

It is 2 to an Sn43Bi alloy. Sn43Bi2Ag which added Ag of weight % It turns out that an alloy is compared with an Sn43Bi alloy and tensile strength, thermal resistance (creep deformation resistance), and wettability are improved. A heat-resistant improvement is understood from the creep deformation resistance being small. Sn43Bi2Ag Sn43Bi2Ag0.05germanium which added germanium further 0.05% of the weight into the alloy An alloy is Sn43Bi2Ag. It compares with an alloy, wettability improves notably, and both tensile strength and thermal resistance (creep deformation resistance) improve further.

[0015] Sn43Bi2Ag It is further 0.5 to an alloy. Weight %Cu and 0.1 Sn43Bi2Ag0.5Cu0.1nickel which added weight %nickel An alloy is Sn43Bi2Ag. It compares with an alloy, and although wettability falls a little, both tensile strength and thermal resistance (creep deformation resistance) improve further. Although it is expected that the thermal resistance of an alloy increases since nickel has oxidation resistance with a high-melting point when nickel is added, since it is thought that nickel forms Bi and an intermetallic compound, ductility decreases

sharply. Sn43Bi2Ag0.5Cu0.1nickel Cu which forms nickel and the solid solution in an alloy was added with nickel, and the ductile fall is suppressed.

[0016] Sn43Bi2Ag It is 0.05 more % of the weight germanium and 0.5 to an alloy. Weight %Cu and 0.1 Sn43Bi2Ag0.05germanium0.5Cu0.1nickel which added weight %nickel An alloy is Sn43Bi2Ag. It compares with an alloy, wettability is improved by \*\*\*\*, and both tensile strength and thermal resistance (creep deformation resistance) improve further.

Sn43Bi2Ag0.05germanium0.5Cu0.1nickel The wettability of an alloy is Sn43Bi2Ag0.05germanium. It is almost equivalent to an alloy.

[0017] Next, Sn58Bi2Ag0.5Cu0.1nickel The result investigated about the wettability at the time of adding germanium is shown in drawing 2 . With meniscography, it evaluated by 210 \*\* using the copper of 1mm phi. When the improvement effect was clearly accepted to 0.3 % and the wetting force exceeded 0.3 % as a germanium addition, it got wet and the force declined rather from initial value. The oxide film by germanium is formed too much, and this is considered to be because for junction nature with copper to fall.

[0018]

[Effect of the Invention] According to the first invention, it is new Sn-Bi. Since a system alloy makes tin a principal component and contains [ a bismuth ] germanium for silver 0.3 or less % of the weight 5 or less % of the weight 30 or 58% of the weight, the low melting point "a solder" of the lead free-lancer who is further excellent in tensile strength, thermal resistance, and wettability in addition to ductility is acquired.

[0019] Moreover, according to the second invention, it is new Sn-Bi. Since a system alloy makes tin a principal component, and silver is contained for a bismuth 30 or 58% of the weight and it contains copper for nickel 1 or less % of the weight 0.2 or less % of the weight 5 or less % of the weight, the low melting point "a solder" of the lead free-lancer who is further excellent in tensile strength, thermal resistance, and wettability in addition to ductility is acquired. In a bismuth, since a new Sn1Bi system alloy makes tin a principal component according to the third invention furthermore, and germanium is contained for silver 5 or less % of the weight 30 or 58% of the weight and it contains copper for nickel 1 or less % of the weight 0.2 or less % of the weight 0.3 or less % of the weight, the low melting point "a solder" of the lead free-lancer who is further excellent in tensile strength, thermal resistance, and wettability in addition to ductility is acquired.

---

[Translation done.]

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.\*\*\*\* shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

---

**DESCRIPTION OF DRAWINGS**

---

[Brief Description of the Drawings]

[Drawing 1] Conventional SUZU bismuth Sn-Bi Diagram showing Bi addition (% of the weight) dependency of elongation (%) per system alloy

[Drawing 2] Sn-Bi Diagram showing the effect of germanium addition (% of the weight) over the wettability of a system alloy

---

[Translation done.]



## \* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

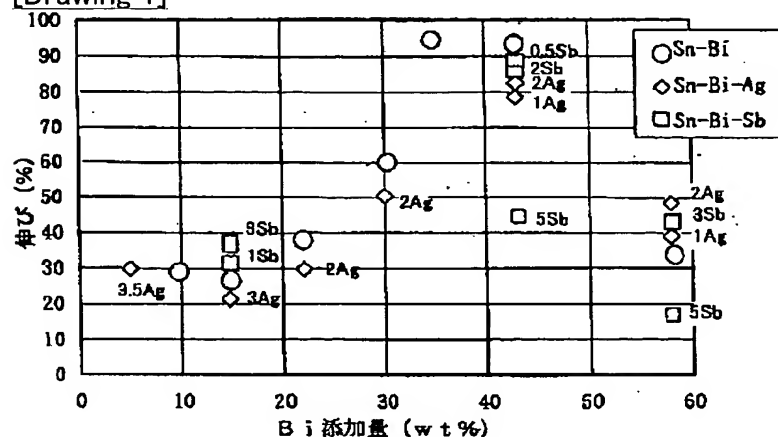
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.\*\*\* shows the word which can not be translated.

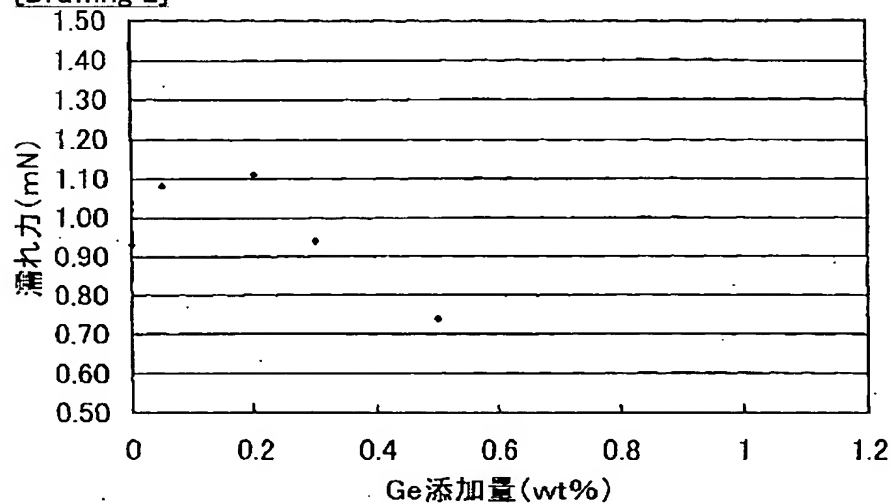
3.In the drawings, any words are not translated.

## DRAWINGS

[Drawing 1]



[Drawing 2]



[Translation done.]



## 【特許請求の範囲】

【請求項1】スズを主成分とし、ビスマス $\leq 30$ ないし $58$ 重量%、銀を $5$ 重量%以下、ゲルマニウムを $0.3$ 重量%以下含有することを特徴とする「はんだ合金」。

【請求項2】スズを主成分とし、ビスマス $\leq 30$ ないし $58$ 重量%、銀を $5$ 重量%以下、ニッケルを $0.2$ 重量%以下、銅を $1$ 重量%以下含有することを特徴とする「はんだ合金」。

【請求項3】スズを主成分とし、ビスマス $\leq 30$ ないし $58$ 重量%、銀を $5$ 重量%以下、ゲルマニウムを $0.3$ 重量%以下、ニッケルを $0.2$ 重量%以下、銅を $1$ 重量%以下含有することを特徴とする「はんだ合金」。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】この発明は電子機器の金属接合において使用される「はんだ合金」に係り、特に鉛を含有しないで公害がなく環境に優しい「はんだ合金」に関する。

## 【0002】

【従来の技術】電子機器等においてははんだ接合を行う際には「はんだ合金」は所望の接合温度を有するとともに接合時のぬれ性が良好であること、また延性、熱疲労強度、耐食性に優れていることが要求される。また「はんだ合金」は環境上の配慮から鉛を含有しないことが望まれる。従来の「はんだ合金」としては、スズ-鉛Sn-Pb合金、スズ-銀Sn-Ag合金、スズ-アンチモンSn-Sb合金、スズ-ビスマスSn-Bi系合金等があげられる。

## 【0003】

【発明が解決しようとする課題】代表的なスズ-鉛Sn-Pb合金である63Sn-37Pb（共晶温度 $183^{\circ}\text{C}$ ）は鉛を含有するので鉛公害を引き起こし環境に優しいものではない。電子装置の「はんだ接合」を行なう場合には装置の構成上、接合温度の異なる複数種類の「はんだ合金」を複数回にわたり使用する必要があり、さらに半導体部品の信頼性を保証するためには半導体部品はピーク温度 $125^{\circ}\text{C}$ 付近までのヒートサイクル耐久性が必要である。

【0004】63Sn-37Pb合金（共晶温度 $183^{\circ}\text{C}$ ）に替わる代表的な鉛フリーはんだであるSn-Ag合金は共晶温度が $221^{\circ}\text{C}$ （ $3.5$ 重量%銀）であり、またSn-Sb合金については熔融温度が $232-245^{\circ}\text{C}$ である。これは鉛フリー合金では熔融温度が高く、はんだづけ作業時に電子部品を過度に加熱し、損傷を与える場合がある。従って鉛フリーはんだとして溶融点がSn-Ag合金やSn-Sb合金より低く、且つ組み立て工程において接合温度の異なるはんだ付けを必要とするときにこれらの合金が溶融しないのはんだ付けできる低溶融温度のはんだ合金が必要となる。

【0005】鉛フリーで且つ溶融温度の低い「はんだ合金」としてスズをベースとしてインジウムを添加したSn-In合金が検討されている。Sn-In合金は共晶点が $118$

$^{\circ}\text{C}$ である。さらに他の鉛フリーの低温「はんだ合金」であるBi-In合金は共晶点が $75^{\circ}\text{C}$ である。上述した鉛フリーの低温「はんだ合金」は耐熱温度が低過ぎる。スズ-ビスマスSn-Bi系合金の一つであるSn7.5Bi2Ag0.5Cu合金は溶融温度が $200-220^{\circ}\text{C}$ で、接合温度として $240-250^{\circ}\text{C}$ を要し、このために電子部品を過度に加熱し損傷を与える場合が生じる。またSn7.5Bi2Ag0.5Cu合金のようにビスマスを数%含有するものは延性が低く、加工性や強度上の問題があり、さらに液相線/固相線の固液共存領域が広く部品によっては接合時にビスマスの濃度偏析を生じ、剥離を生じる場合（リフトオフ現象）もある。

【0006】図1は従来のスズ-ビスマスSn-Bi系合金につき伸び（%）のBi添加量（重量%）依存性を示す線図である。図中○はSn-Bi合金の示す特性点、◇はSn-Bi-Ag合金の示す特性点、□はSn-Bi-Sb合金の示す特性点である。伸び測定におけるひずみ速度は $0.2\text{ \%}/\text{s}$ である。Sn-Bi合金（○）の延性はBi添加量とともに増し、ピークを過ぎると共晶組成（Bi $58$ 重量%）に向けて漸減する。共晶組成における融点は $139^{\circ}\text{C}$ である。Bi $30-50$ 重量%の範囲ではSn-Bi合金の伸びは $50-90\text{ \%}$ である。Sn-Ag合金（ $3.5$ 重量%銀）は伸びが $20-30\text{ \%}$ であり、また鉛フリーのスズ-ビスマスSn-Bi系合金であるSn7.5Bi2Ag0.5Cu（溶融温度は約 $200^{\circ}\text{C}$ ）が伸び $10\text{ \%}$ を示すことを考慮すると、Bi $30-50\text{ \%}$ の範囲でのSn-Bi合金の伸びは充分に大きい。これはSn-Pb「はんだ合金」と同等レベルの延性である。Sn-Bi-Ag合金（◇）の延性はBi $30-58$ 重量%の範囲でSn-Bi合金（○）よりも低下する傾向があるがまだ充分に大きいことがわかる。

【0007】SnにBiを $30$ ないし $58$ 重量%添加したSn-Bi合金は上述のように延性が良好であるがさらに溶融温度が低いことも知られている。このようなBiを $30$ ないし $58$ 重量%含むSn-Bi合金にさらにSb、AgまたはGeを加えると、得られたSn-Bi系合金の耐熱性（なかでもクリープ特性）が向上する。しかしながらSb、AgまたはGeのうちSbとGeを添加する場合は濡れ性が悪く、AgとGeを添加する場合は耐熱性は改善されるが濡れ性は明確ではないという問題があった。

【0008】この発明は上述の点に鑑みてさなれその目的は、低融点で延性の良好なスズ-ビスマスSn-Bi合金を改良して、融点が低く延性が良好である上に耐熱性と濡れ性にも優れる鉛フリーの低融点「はんだ合金」を提供することにある。

## 【0009】

【課題を解決するための手段】上述の目的は第一め発明によればスズを主成分とし、ビスマス $\leq 30$ ないし $58$ 重量%、銀を $5$ 重量%以下、ゲルマニウムを $0.3$ 重量%以下含有することにより達成される。第二の発明によればスズを主成分とし、ビスマス $\leq 30$ ないし $58$ 重量%、銀を $5$ 重量%以下、ニッケルを $0.2$ 重量%以下、銅を $1$ 重量%以下含有することにより達成される。

【0010】第三の発明によればスズを主成分とし、ビスマスを30ないし58重量%、銀を5重量%以下、ゲルマニウムを0.3重量%以下、ニッケルを0.2重量%以下、銅を1重量%以下含有することにより達成される。スズを主成分とし、ビスマスを30ないし58重量%含有するスズ-ビスマスSn-Bi合金は熔融温度が140ないし180℃近辺にあり、他の金属元素を添加したSn-Bi系合金は低融点の「はんだ合金」となる。

【0011】スズを主成分とし、ビスマスを30ないし58重量%含有するスズ-ビスマスSn-Bi系合金の延性はSn-Pb「はんだ合金」と同等レベルである。スズを主成分としビスマスを30ないし58重量%含有するスズ-ビスマスSn-Bi合金にAgとGe、AgとNiとCu、またはAgとGeとNiとCuを所定の割合で添加すると、熔融温度特性や延性に加えてさらに耐熱性と濡れ性の良好な「はんだ合金」が得られる。

【0012】

【発明の実施の形態】「はんだ合金」は、Sn、Bi、Ag、Ge、Ni、Cuの各原料を電気炉中で溶解して調製することができる。各原料は純度99.99重量%以上のものを使用し

た。「はんだ合金」成分のうちSnは主成分である。Biは30ないし58重量%以下、Agは5重量%以下、Geは0.3重量%以下、Niは0.2重量%以下、Cuは1重量%以下が添加される。合金組成はSnを主成分としてBi30ないし58重量%以下とAg5重量%以下とGe0.3重量%以下を含むもの、Snを主成分としてBi30ないし58重量%以下とAg5重量%以下とNi0.2重量%以下とCu1重量%以下を含むもの、さらにSnを主成分としてBi30ないし58重量%以下とAg5重量%以下とGe0.3重量%以下とNi0.2重量%以下とCu1重量%以下を含むものである。

【0013】実施例

引っ張り強度試験は直径3mmの試験片を用い、引っ張り速度0.2%/sで室温において実施した。また耐熱性を調べるために同形状の試験片を用い、負荷応力0.2kg/mm<sup>2</sup>でクリープの変形抵抗を測定した。濡れ性はメニスコグラフ法で評価した。一例としてSn22Bi合金系やSn43Bi合金系につき引っ張り強度、伸び、クリープ変形抵抗、濡れ力を測定した結果が表1に示される。

【0014】

【表1】

材 料 組 成	凝固開始/固相 (℃)	引っ張り強度 (kg/mm <sup>2</sup> )	伸 び (%)	クリープ変形抵抗 (%/h)100℃	濡れ力 (mN) 230℃
Sn22Bi	202/138	8.3	38	2.2	
Sn22Bi2Ag0.2Ni	194/136	6.4	2.4		1.23
Sn43Bi	167/139	5.5	93	6.0	0.91
Sn43Bi1Ag	158/135	5.9	79		
Sn43Bi2Ag	160/136	6.0	84	5.4	1.08
Sn43Bi5Ag	159/138	6.2	79		
Sn43Bi2Ag0.05Ge	161/138	7.0	86	4.5	1.2
Sn43Bi2Ag0.1Ge	162/138	6.6	73	2.9	
Sn43Bi2Ag0.5Cu0.1Ni	160/138	7.5	70	4.5	0.99
Sn43Bi2Ag0.5Cu0.1Ni0.05Ge	159/138	6.7	58	4.2	1.21
Sn43Bi2Sb	182/141	5.9	87	4.3	0.76
Sn43Bi2Sb0.1Ni	175/140	6.2	2.9		
Sn58Bi	139	8.4	35	3.3	0.75
Sn58Bi2Ag	139	7.0	49	2.7	0.82
Sn58Bi2Ag0.05Ge	140/138	6.5	46	2.3	1.02
Sn58Bi2Ag0.5Cu0.1Ni	143/138	5.9	63	1.9	0.93
Sn58Bi2Ag0.5Cu0.1Ni0.05Ge	140/136	6.1	59	1.6	1.06

Sn43Bi合金に2重量%のAgを添加したSn43Bi2Ag合金はSn43Bi合金に比し引っ張り強度、耐熱性(クリープ変形抵抗)、濡れ性が改善されることがわかる。耐熱性の改善はクリープ変形抵抗が小さくなっていることからわかる。Sn43Bi2Ag合金にさらに0.05重量%Geを添加したSn

43Bi2Ag0.05Ge合金は、Sn43Bi2Ag合金に比し、濡れ性が顕著に向上し、引っ張り強度、耐熱性(クリープ変形抵抗)はともにさらに改善される。

【0015】Sn43Bi2Ag合金にさらに0.5重量%Cuと0.1重量%Niを添加したSn43Bi2Ag0.5Cu0.1Ni合金は、Sn

【0018】

【図2】 Sn-Bi 系合金の濡れ性に対するGe添加量（重量%）の効果を示す線図

Figure 1 is a scatter plot showing the relationship between the amount of Bi added (wt %) on the x-axis and the yield (%) on the y-axis. The x-axis ranges from 0 to 60 wt %, and the y-axis ranges from 0 to 100 %.

The legend indicates three data series:

- Sn-Bi
- ◇ Sn-Bi-Ag
- Sn-Bi-Sb

The data points are labeled with their respective compositions:

- 3.5Ag (Sn-Bi-Ag)
- 1Sb (Sn-Bi-Sb)
- 2Ag (Sn-Bi-Ag)
- 3Ag (Sn-Bi-Ag)
- 5Sb (Sn-Bi-Sb)
- 2Ag (Sn-Bi-Ag)
- 3Sb (Sn-Bi-Sb)
- 1Ag (Sn-Bi-Ag)
- 5Sb (Sn-Bi-Sb)

【図2】

